



# **EXAMINATIONS 2015 / 2016**

## **ARHOLIADAU 2015 / 2016**

**Semester 2**

**FACULTY OF:** Architecture, Computing & Engineering  
(School of Automotive Engineering)

**NAME OF COURSE/PROGRAMME:** BEng Automotive Engineering  
BEng Motorsport Engineering  
BEng Motorcycle Engineering

**YEAR OR LEVEL:** Level 5

**NAME OF MODULE/UNIT/EXAM PAPER:** Powertrain and Control

**MODULE NO:** M5X00402

**DATE OF EXAMINATION:** 19<sup>th</sup> May 2016

**START TIME:** 09:00

**FINISH TIME:** 11:00

**TIME ALLOWED:** 2 hours

### **INSTRUCTIONS TO CANDIDATES:**

Students should attempt 3 out of 4 questions.

Note that in all your answers, marks will be awarded for detailed explanation of the calculation steps.

## QUESTION ONE

You are required to design the intake system for a Formula 3 in-line 4 cylinder 2 litre naturally aspirated engine. The systems are to be designed to help both maximum torque which is at 5600 RPM and maximum power which is at 7200 RPM.

You can assume no end correction effects when calculating intake lengths.

Assume that the inlet valve duration is  $300^\circ$  and that maximum opening point (M.O.P.) is  $108^\circ$  ATDC (after top dead centre) and the CAM is symmetrical.

Assume that the speed of sound at  $20^\circ\text{C}$  is 330 m/s and that speed of sound in the exhaust system is related to that in air at  $20^\circ\text{C}$  according to the square root of the ratio of the absolute temperatures.

- (a) Assuming that the inlet runners are fed from a common plenum, calculate the length from the valve to the inlet trumpet that best helps achieve maximum power.  
(5 marks)
- (b) If the CAM timing were to be changed to opening  $100^\circ$  BTDC with a duration of  $330^\circ$  what effect will this have on the inlet length?  
(5 marks)
- (c) Look at the first 4 harmonics for each CAM profile and discuss which profile would be more suitable for –
  - 1) High Speed tracks.
  - 2) Low speed tracks with corners.  
(6 marks)
- (d) Discuss how you would change inlet valve duration of the original CAM profile to increase RPM of maximum torque to 6100 RPM if it is not possible to change inlet runner lengths.  
(4 marks)

## QUESTION TWO

You are required to design the exhaust system for a Formula 3 in-line 4 cylinder 2 litre naturally aspirated engine. The systems are to be designed to help both maximum torque which is at 5600 RPM and maximum power which is at 7200 RPM.

You can assume no end correction effects when calculating exhaust lengths and the standard exhaust setup is a 4 into 1 manifold.

Assume that the exhaust valve duration is  $300^\circ$  and that maximum opening point (M.O.P.) is  $104^\circ$  BTDC (before top dead centre) and the CAM is symmetrical.

Assume that the speed of sound at  $20^\circ\text{C}$  is 330 m/s and that speed of sound in the exhaust system is related to that in air at  $20^\circ\text{C}$  according to the square root of the ratio of the absolute temperatures.

- (a) Estimate exhaust gas temperatures in the exhaust valve and at the 4 into 1 collector. Calculate the mean manifold exhaust gas temperature and the mean speed of sound in the exhaust manifold.  
(2 marks)
- (b) Calculate the length from exhaust valve to collector assuming the manifold length is to help maximum power. Discuss the effect of Harmonics and explain your choice of exhaust length.  
(6 marks)
- (c) Calculate the internal diameter of the primary exhaust manifold, stating your assumptions.  
(4 marks)
- (d) Looking at a 4 into 2 into 1 silencer for circuits needing a wider spread of torque out of the corners, calculate suitable lengths of the primary & secondary manifold pipes to achieve better mid-range performance. Keep overall manifold length same as 4 into 1 and calculate new intermediate primary length to fill in the harmonics.

(8 marks)

### QUESTION THREE

You are asked to carry out a study of valve dynamics of a camshaft/cam follower system using the supplied table of valve lift (mm) against crank angle (degrees) data.

Assume that the total moving mass is 0.1 kg and that the contact force between the camshaft and the cam follower becomes zero at full lift @ 8000 RPM (crank).

You are asked to calculate the spring stiffness in N/m needed to achieve the desired float at 8000 RPM assuming that the initial compression of the spring is 5mm.

Carry out the answer in the following stages –

- a) Calculate valve velocity in mm/° at the provided lifts.  
(2 Marks)
- b) Calculate valve acceleration in mm/°/° at the provided lifts.  
(2 Marks)
- c) Calculate the acceleration in m/s/s at the provided lifts at 8000 RPM.  
(4 Marks)
- d) Write down the equation of motion of the valve dynamic motion.  
(3 Marks)
- e) Show typical graphs of lift, velocity and acceleration and show what sign the acceleration is at full lift.  
(3 Marks)
- f) Calculate the required valve spring stiffness in N/m  
(6 Marks)

| Crank Angle ATDC (°) | Valve Lift (mm) |
|----------------------|-----------------|
| 106                  | 7.988           |
| 107                  | 7.994           |
| 108                  | 7.998           |
| 109                  | 8.000           |
| 110                  | 8.000           |
| 111                  | 7.998           |
| 112                  | 7.994           |
| 113                  | 7.988           |

#### QUESTION FOUR

You are asked to study dyno data from a 4 cylinder 4 stroke, 1.6l GDI turbo engine. The fuel calorific value is 43.391 MJ/kg. For the calculations assume that 1 BAR =  $10^5$  PA and that the Stoichiometric Air/Fuel ratio by mass = 14.5.

The data is enclosed in the following table -

| DYNO_SPD | TORQUE | AFR_HOR | FUELMASS |
|----------|--------|---------|----------|
| rpm      | Nm     | -       | kg/h     |
| 1001     | 129.9  | 15.2    | 3.51     |
| 1500     | 204.9  | 15.1    | 8.33     |
| 1700     | 233.8  | 15.2    | 10.96    |
| 2002     | 230.5  | 14.8    | 12.71    |
| 2499     | 250    | 14      | 17.7     |
| 3000     | 252.7  | 12.5    | 23.95    |
| 3500     | 249.9  | 12.7    | 26.95    |
| 4002     | 253.1  | 12.1    | 31.81    |
| 4500     | 248.7  | 11.8    | 36.86    |
| 5000     | 238.7  | 11.3    | 41.66    |
| 5499     | 222.2  | 11      | 44.95    |
| 5700     | 217.8  | 10.9    | 46.46    |
| 5997     | 207.8  | 10.8    | 47.94    |

- a) Calculate the power at each RPM.  
(3 Marks)
- b) Calculate the fuel equivalence ratio at each RPM.  
(2 Marks)
- c) Calculate the Lambda at each RPM.  
(2 Marks)
- d) Calculate the BSFC in gms/KW.hour at each RPM.  
(4 Marks)
- e) Calculate overall engine efficiency at each RPM.  
(4 Marks)
- f) What would you do to the engine to achieve high RPM engine efficiency?  
(2 Marks)
- g) Calculate BMEP in BAR at each RPM.  
(3 Marks)

